A DESIGN FOR COMMERCIAL PRODUCTION OF CATFISH (*Clarias lazera*) IN MULTIPLE CAGES

by

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INTRODUCTION

Cage fish culture is defined as the rearing of fish stocks, generally from juvenile to market size, in a totally enclosed water volume through which a free water circulation is maintained (Coche, 1982). Together with raceway and tank culture, fish culture in cages constitutes an intensive rearing system that is perfectly adaptable to commercialization. Of the intensive systems mentioned, however, it has the least initial capital cost. The cages are normally constructed with locally available materials and can be set up in most water bodies without any special arrangement as would be necessary for tanks or raceways. Ita, *et. al.* (1985) prepared a checklist of inland water bodies in Nigeria. Most of these water bodies are not put into any economic use and can be utilized for cage culture, thus reducing the pressure on land resources. Land-based aquaculture is limited to the availability of land near sources of adequate and suitable water supply. In cage culture, there is optimum utilization of artificial food for growth, reduced fish handling and mortalities, and complete harvest of fairly uniform product.

The history of cage culuture can be traced to Southeast Asia, where, according to Beveridge (1984), it originated as a traditional method used by fishermen to keep commercial fishes in bamboo cages and baskets until ready for transport to market. In captivity, the fishes were fed kitchen scraps and were found to grow well. The practice was on for years in Kampuchea and Vietnam (Beveridge 1984). Cage culture has since moved from the era of a holding device for fishermen's catches to a highly efficient method of growing fish to marketable size. Chan (1977) described the design and construction of floating marine fish cage in Hong Kong. Sodikin (1977) and Teng, *et. al.* (1977) did so for Indonesia and Malaysia.

Cages and enclosures of different designs have been developed in recent years and successfully used Salmons (Oncorhynchus, Salmo), trout (Salmo spp), channel catfish (Ictalurus) and yellowtail are the most commonly used species for modern cage culture (FAO, 1976). A production rate as high as $173 kg/m^3$ has been reported for Channel catfish in the United States of America (Collins, 1972). Cage culture trials have been carried out in Egypt (Ishak, 1979), Tanzania (Ibrahim 1976), Ivory Coast (Coche 1977, 1979) and Kainji Lake (Konikoff, 1975; Ita, 1976). In all the cases, the conclusion was that this system was potentially suitable for intensive culture of fish especially the tilapia.

The use of the catfish (Clarias lazera) in cage culture does not appear to have been so well investigated. As cage culture is becoming more and more important in awareness and as Clarias lazera is a choice species that can be used in this culture method, it is necessary that relevant practical information be made available.

The dual purpose of this paper is first, to report on preliminary study on the appropriate economical feeding rate which would enhance the growth of catfih (Clarias lazera) in cages, and secondly, the paper serves to introduce a design of a practical floating platform that can be used for culture of fish in multiple cages. Feed cost is the single highest annual production cost in cage culture averaging over 55% (FAO, 1976). Feeding rate therefore should be at the economic level. Balarin and Hatton (1979) reported Moriarty and Moriarty (1973) as having developed a formula for the feeding rate which they successfully used to feed Sarotherodon niloticus in cages in Lake George, Uganda. No such relationships have been evolved for cage culture of Clarias lazera.

MATERIALS AND METHODS

The Floating Platform

The study was carried out at the Lyi-ojoo Lake, Nike a few kilometers from the Anambra State Capital, Enugu. A floating fish farm has been established there by the State Ministry of Agriculture using platform and cages described in this study.

Figure I shows the design of the platform which is made of wooden planks mounted on sealed empty oil drums which provide the floatation. The planks are hardwood with the normal dimensions of 1" x 1ft x 12ft. They are arranged as shown in the figure, such that 20 cages can be carried at a time as well as four working men. Attachment of each drum to the platform is achieved by means of three 3" belts which have been welded on to the drum and passed through holes drilled at the required positions of the wood and then tightened with fitting nuts. The details of the calculations that gave the number of drums required to float the platform such that the cages will have 0.25m above water, are shown in Appendix I. The calculations show that 18 drums are required. However, it was observed from experience that after a short time, the middle portion of the platform would sag. This was corrected by fixing a row of six extra drums in the middle as shown in figure I. Three extra pieces of planks measuring 6ft. (1.83m) for each ~~of~~ two and 7ft (2.14m) for the third piece were needed for this. The platform including the drums were coated with bituminous black paint, for protection.

When launching into water, the platform is placed such that the side shown as right elevation (Fig.1) is farthest from the shore while the opposite end with double line of planks is nearest the shore. Depending on the shoreline and how far out there is deep enough water, an approach ramp can be attached to the platform. This is in the form of three lines of planks attached to the drums. The length of this approach ramp depends on the distance it has to cover so that the platform is placed where the hanging cages would have good clearance from the water bed. The floating platform is anchored by means of nylon ropes tied to either trees or pipes that are fixed securely on shore.

The cages used in this study were made of 1" angle iron frames and clicken wire mesh sides. The mesh was 1" (25mm) and each cage was 1m x 1m x 1.25m with a bottom made of perforated galvanised sheet and a top of galvanised mosquito proof in a wooden frame. This top is hinged on one side so that the cage can be opened completely or locked with a staple. At the four corners of the cage and at the 0.25m mark from the top, are fixed four loops made of iron rods for use as handles to aid in lifting the cage out of water. To attach the cage to the platform are four springs (each 10cm long) that hook on from holes in the top rim of the cage to spring hooks fixed in the wood of the platform. Water level comes up to the 1m. mark of the cage so that a volume of $1m^3$ is inside water. The cage, like the platform, is coated with bituminous black paint. For this study, the hanging cages were 1.3m clear from the bottom of the lake.

Feeding Rate Study

Clarias lazera fingerlings of 50g. range were collected from the wild and stocked in six cages at the rate of 50 fish per cage. They were fed on NIOMR pellets (of 33% crude protein) at varying ratio levels of 3%, 6% and 9% of fish body weight. The daily ration was applied in two feedings. Two cages were used for one feeding rate and the results averaged for each rate. The fish in each cage were sampled for weight after 28 days by weighing ten randomly selected fish. The estimated fish biomass was then used to adjust the amount of feed applied.

At the end of the experimental period of 55 days, the final measurements were used to compute the following parameters:

(i) Specific Growth Rate $= \dfrac{\log_e W_2 - \log_e W_1 \times 100\%}{d}$

Where W_1 = wt(g) at stocking

W_2 = wt(g) at end of experiment

d = culture period (days)

(ii) Food Conversion Ratio (FCR) $= \dfrac{\text{Amt. of feed applied(g)}}{\text{Increase in fish wt(g)}}$

(iii) Protein Efficiency Ratio $= \dfrac{\text{Increase in fish wt(g)}}{\text{g. crude protein fed}}$

Statistical tests of significance were carried out using Duncan's Multiple Range Tests. The temperature and pH of the surface water of the lake were measured with a mercury thermometer and a digital pH meter, respectively. Working from the platform, the water was collected in plastic bottles and the readings taken within 5 minutes of collection. This exercise was done once a week and the mean values for the period were 25°C ± 1.0 for the temperature and 6.90 ± 0.75 for the pH.

RESULTS

Table 1 shows the results obtained in the study. Survival of the fish at the end of the study period was high with the least value of 98.2% recorded for 6% feeding rate. The specific growth rate (SGR) was highest for the 6% feeding rate and lowest for the 9% rate. The values, however, were not significantly different. The food conversion ratio (FCR) increased as the feeding rate increased. The FCR for 9% feeding rate was significantly different from the rest. The change between the 3% and 6% rates, however, was not significant. The protein efficiency ratio (PER) decreased as the feeding rate increased. There was a significant change between the PER for 3% and 9% rates, but the change between 3% and 6% or between 6% and 9% was not significant.

The relationship between the FCR, SGR and the three ration levels is shown in Fig. 2. From this figure, it can be seen that the optimum ration level under the conditions of this experiment was 6.6%.

Table 1 - Growth of *Clarias lazera* fingerlings fed at three feeding levels

Daily Feeding Rate % of fish biomass	3%	6%	9%
Initial Average Weight(g)	50.1	38.9	50.1
Final Average Weight(g)	110.9	105.5	101.0
Culture Period (days)	55	54	55
Number Stocked	50	55	50
Number Recovered	50	54	50
% Survival	100	98.2	100
Quantity of feed applied(g)	5,880	10,125	14,940
* Specific Growth Rate SGR) %	1.44^{a}	1.85^{a}	1.27^{a}
* Food Conversion Ratio (FCR)	1.93^{b}	2.76^{b}	5.87
* Protein Efficiency Ratio (PER)	1.57^{c}	1.10^{cd}	0.52^{d}

* Figures with the same subscript are not significant ($P = 0.05$).

DISCUSSION

Daily Ration Level

There is hardly any available published work on the culture of Clarias lazera in cages. However, the effects observed in this study correspond to the effects on SGR, FCR and PER observed in other species with changing ration levels. Working with Carp fingerlings of about 52g and in circular tanks, Ejike and Ofojekwu (1983) made similar observations using three ration levels of 1%, 2% and 3% body weight. The growth rate was highest near the optimum ration level and declined to both sides of it. The PER decreased with ration size while the ratio of conversion of food to flesh improved in value with lower ration level. Stetfen (1981) in a review of protein utilization by rainbow trout (Salmo gairdneri) and carp (Cyprinus carpio), calculated the data from Huisman (1976) and showed the same trends - the growth rate was highest near the optimum ration level, the FCR increased and PER decreased with ration size. However, Jauncey (1982) in a review of carp nutrition, used the data from Jauncey (1979) to show that at a given temperature, the SGR increased as the ration size increased even up to 9% body weight. He noted, though, that increasing the feeding level resulted in proportionately smaller increases in SGR which suggested that a maximum was being approached. Other authors sited by him had observed that for both sockeye salmon and carp, increasing the feeding rate at any one temperature increased growth up to an asymptote beyond which it remained constant.

The observations made on the SGR, FCR and PER as the ration size increased should be expected from the definition of those parameters. At the low feeding level, there is not enough food for growth and the FCR will naturally be determined as a low quantity. The PER at this low ration level will show high utilization of the little amount of protein present, at least for maintenance. As the ration size is increased, more food is available for growth, the FCR increases in value and PER decreases. Beyond the optimum ration level, there is high induced metabolic rate and consequent reduction in the amount of energy available for growth (Jauncey, 1982). Also, as the meal size increases, the absorption efficiency decreases (NAS, 1983) with the overall effect of less nutrients being available for growth metabolism. Thus the SGR and PER decrease. At the optimum level of the ration, the fish is growing at the rate at which food is being converted to flesh. This then is the economic level of feeding, and in this study the optimum feeding level has been found to be 6.6% body weight given the experimental conditions.

The best feeding rate in cage culture is usually higher than in ponds. This is because, apart from food losses through the cage, the system is by nature intensive and the fish depends almost solely on artificial feeds rather than the natural food in the environment. Phillips et. al. (1983) showed with data from various authors that the FCR for ponds are generally lower than for cages. For tilapia, Jauncey and Ross (1982), citing Macintosh,(1982) and Macintosh and De Silva. (1982), states that at 28°C, the 50g fish will not accept more than 3% of the body weight. In cages, however, Coche (1979) reports that for tilapia of less than 40g the best feeding rate was 6% of the body weight, and for fish above this size the daily ration should not exceed 4% of the biomass in order to obtain a reasonable conversion rate. Coche (1982) reports the recommendations of other authors for tilapia in cages. For fish of 50g size he reports as follows:

a) Melard and Philippart (1980) recommends 6% reducing to 4.5% for fish in the range 40g-100g.

b) Guerrero (1980) recommends 5% for fish less than 50g. and 4% for fish in the range 50g-100g.

The above recommendations for cages were higher than the 3% for ponds with fish of the same size.

Equivalent data are not available for Clarias lazera in cages, but for pond culture Viveen, et. al. (1986) recommends feeding at 3% body weight for fish in the size range 24g - 55g. Also, NAS (1983) recommends the same 3% of body weight for daily feeding of channel catfish at temperature range of 21°C. Judging from the observations discussed above for tilapia in both cage and pond culture, the value of 6.6% body weight as obtained for Clarias lazera in this study, appears reasonable when compared with the 3% recommended for the species in pond culture.

Commercial Use of the Floating Platform

Published data on cage production of Clarias lazera are not available, unlike the tilapias where a fair amount of information has been published. To assess the usefulness of the platform and cages used in this project for commercial purposes, the production data as known for tilapia can be used. Balarin and Haller (1982) summarized the stocking and production programme for tilapia in cages as follows:

> fingerlings of 20 - 40g stocked with initial biomass of 20kg/m³ reach harvestable size (200g) with annual production rate of 200 - 300kg/m³ and FCR of 2-2.5. Locally, tilapia fingerlings cost one kobo per gramme. Thus 20kg. will be ₦200.00. Shang (1981) showed that the cost of feed per unit of fish production (C_f) can be given by:
>
> $$C_f = R\,P_f$$
>
> where R = Food Conversion Ratio (FCR) and P_f = unit price of feed.

NIOMR pellets were purchased at about ₦900/tonne. ₦100/tonne should be added for transportation, etc. This brings the price to ₦1000/tonne or ₦1/kg. With FCR of 2.5, the feed cost per unit of fish production becomes ₦2.5/kg. of fish produced. Then for annual production of 200kg/m³, the feed cost becomes ₦500/m³.

The materials used for the construction of the platform are as follows:

Material	Quantity
a) planks (1" x 1' x 12') hard wood	36
b) sealed drums	24
c) 3 bolts and nuts with washers	114
d) spring hooks	80
e) springs (30cm)	19
f) bituminous black paint	40 gallons

The cost of the above materials and labour for the construction and installation of one platform came to ₦3,000.00 The cost of materials and construction of one cage was ₦350.00, so that for 20 cages the cost was ₦7,000.00. Thus the total capital cost of one Platform with 20 cages was ₦10,000.00. Like other agricultural projects, the bigger the size of the farm, the more economical the venture. It is suggested here that for a good size, a floating fish farm should have at least 10 platforms with 200 cages. This will be at a cost of ₦100,000. The unit of production is one cage or 1m³. The capital cost per unit of production, therefore, is ₦500/m³.

The labour required for the maintenance of the farm is put at 4 men earning a total of ₦9,600 per annum. Thus labour cost per unit of production is ₦48/m³. Assuming loan repayment and other expenditure to be 10% of Capital cost, this comes to ₦50/m³ per annum.

The best commercial fish farm in Anambra State, is in Anambra Local Government Area and it produces tilapia and other species. Sales are to wholesale buyers who then re-sell in the market. The farm gate price of tilapia in this fish farm is ₦5/kg. The official price list as at July, 1986 issued by the Anambra State Ministry of Trade and Cooperatives shows the market price of fresh fish to be ₦10/kg on the average. Using the figure of ₦5/kg a production of 200kg/m³/yr will give ₦1,000/m³/yr.

sing the above considerations, the annual revenue and costs er unit of production(m^3) for the floating fish farm with) platform and 200 cages, are given thus:

. Annual Production Revenue:

roduct	Quantity	Unit Price	Revenue
'ish (Tilapia)	200kg/m^3	₦5.00/kg	₦1,000/m^3

3. Annual Operating Costs

Item of Expenditure	Quantity	Unit Price	Cost	% Total
Fingerlings	20kg/m^3	₦0.01/g	₦200/m^3	25.00
Labour	4 workers	₦2400/annum	₦48/m^3	6.00
Feed	FCR=2.5	₦1.00/kg	₦500/m^3	62.50
Other expenditure (loan repayment, etc)	10% of Capital		₦50/m^3	6.25
Total			₦798/m^3	
		Approx	₦800.00	

C. Economic Indicators

i) Profit/m^3 = ₦1,000 - ₦800 = ₦200/m^3/annum

ii) Return on investment = $\frac{₦200}{₦500} \times 100 = 40\%$

iii) Payback period = $\frac{₦500}{₦200}$/annum = 2.5 years.

The indicated payback period is 2.5 years. The materials used for this study can last up to a minimum period of 5 years with little maintenance e.g. repainting of the cages every year. To increase the profit margin, the cages can be made with cheaper materials like wooden frames. Furthermore, the above economic considerations have been done with tilapia which constitute one of the cheapest types of fish in the country. Using a better priced fish species will increase the profit margin. It is therefore suggested that the floating platform described in this paper can be used for commercial fish production in cages.

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Appendix I

Calculations To Get The Number of Drums Required For A Floating Platform

Data Given

i) **Drums:** diameter = 0.55m, thus radius (r) = 0.275m length of drum = 0.881m wt. of empty drum = 40kg. No. drums required to achieve desired.

ii) **Persons** (human workers): ave. wt. = 80kg

Maximum of 4' persons at a time i.e.

maximum wt. of human workers = 320kg

iii) **Cage** No. cages = 20

Each cage made of angle iron (two lengths of 20ft. each. One lenth weights 10kg)

Wt. of each cage = 20kg + 3kg = 23kg

(where 3kg is a tolerant wt. for weld joints)

Then total wt. of cages = 20 cages x 23kg

= 460kg.

Each cage attached to platform such that 0.25m will be above water.

(iv) Platform 34 No. planks (hard wood) 1" x 12" x 12ft

i.e. 1 cu. ft.

£t 33lb/cu.ft., each plank weighs 33lb.

∴ 34 planks will weigh 34 x 33lb

= 1122lb

= 510kg.

Calculations

a) To get volume of water displaced per drum:

i) Area of submerged section of drum:

i.e. area of sector CDBA:

AO = (0.275 - 0.249)m = 0.026m

From triangle AOB,

$$\text{Cor angle AOB} = \frac{0.026}{0.275} \text{ (i.e. } \frac{AO}{OB})$$

$$= 0.09455$$

angle AOB = 84.58 degrees.

Then angle COB = 2 x angle AOB = 169.15 degrees

$$\text{Area of sector COB x} = \frac{\text{angle COB}}{360} \times TI \times x^2$$

$$= 0.112m^2$$

Now $AB^2 = OB^2 - AO^2 = 0.074949m^2$

thus AB = 0.274m

CB = 2 x AB = 0.518m

Area of triangle CBO = ½(CB) x AO = 7.124×10^3 m^2

Area of sector CB x = Area of sector COBy - Area of triangle CBO = $0.105m^2$

X - sectional area of drum i.e. area CDBX = Ti x R^2

$= 0.238m^2$

Area of sector CDBA = Area CDBX - Area CBX

$= \underline{0.133m^2}$

ii) Volume of submerged section of drum =

Area CDBA x length of drum = $117m^3$

iii) An object displaces its own volume in water

$\therefore$ volume of water displaced per drum =

$117m^3 = 11700\ cm^3$ (c.c.)

b) To get weight of water displaced per drum:

1 cc of water at 4°C weighs 1g. (p.001kg)

$\therefore$ 117000cc of water at 4°C weigh 117kg.

c) Weight of water displaced by n drums will therefore be 117n kg.

d) From the principle:

$W_{t.}$ of fluid displaced = downward force.

Total downward force = wt. of water displaced by n drums.

$\therefore$ wt. of platform + wt. of drums + wt. of human workers + wt. of cages = wt. of water displaced by n drums.

Thus 510kg + 40n kg + 320kg + 460kg = 117n kg

77n = 1290

n = 17 drums.

To allow for margin of safety and also for symmetry, the number of drums required will be 17 + 1 = 18 drums.

Courtesy of Engr. J. E. Amadi
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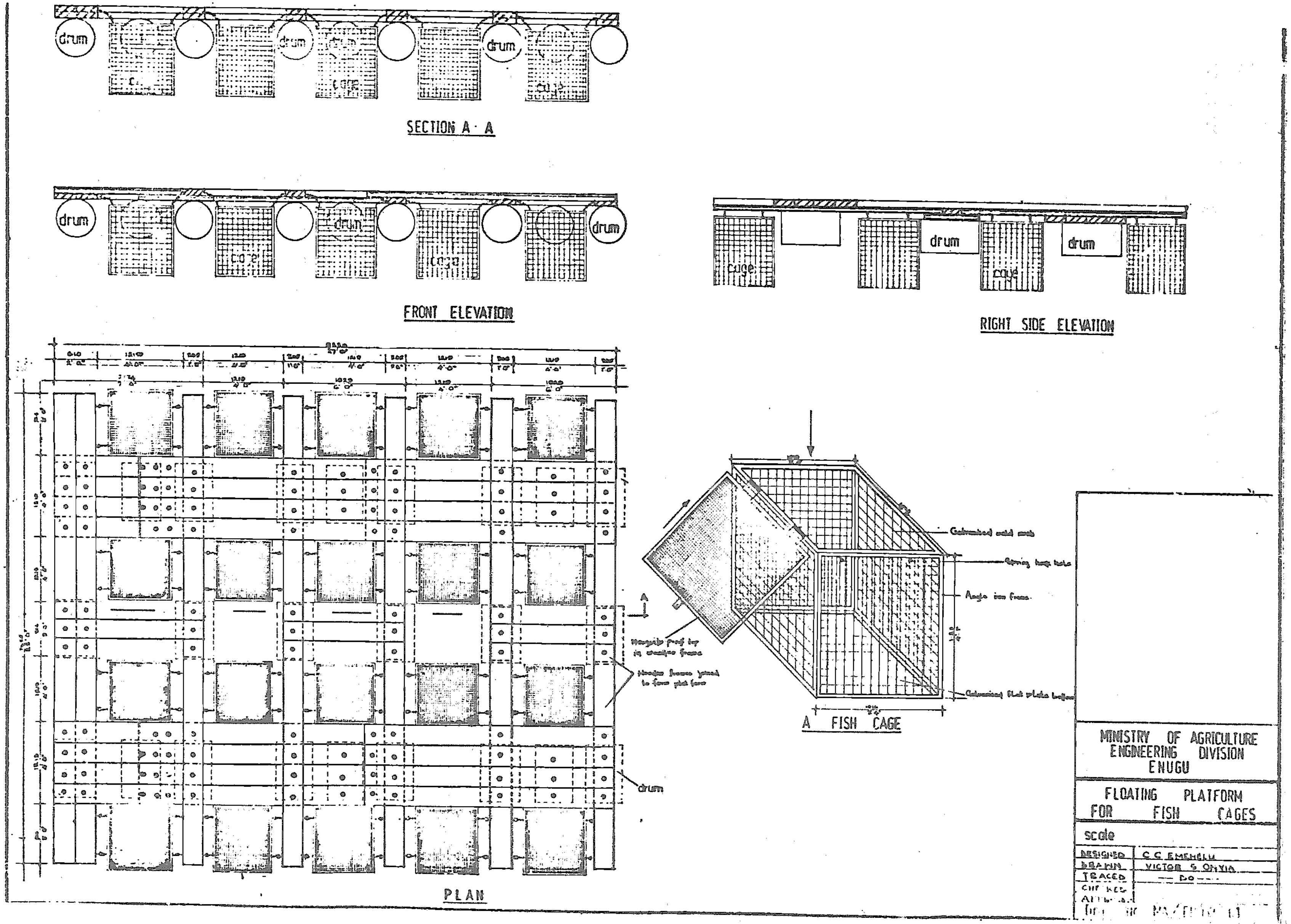
drum
cage
SECTION A · A
FRONT ELEVATION
RIGHT SIDE ELEVATION
PLAN
A FISH CAGE
MINISTRY OF AGRICULTURE
ENGINEERING DIVISION
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FLOATING PLATFORM
FOR FISH CAGES
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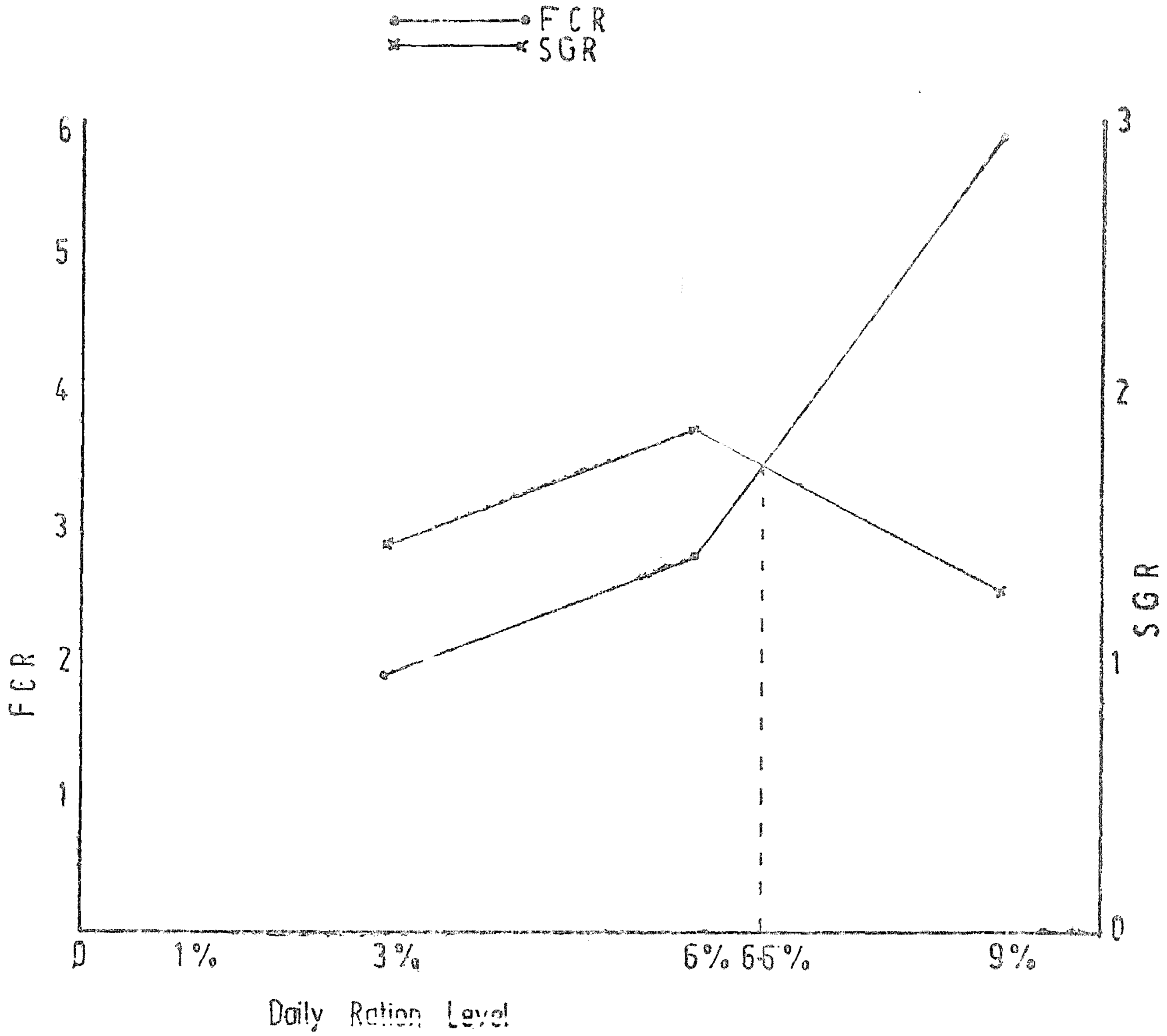

Fig 2. Relationship between FCR, SGR and the ration levels.